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# Actor-to-actor tensions influencing waste management in building refurbishment projects: a service ecosystem perspective

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## ABSTRACT

Waste management in the Architecture, Engineering and Construction (AEC) industry has been a major research topic owing to the AEC industry being one of the top contributors of waste generation. However, research has primarily focused on new build and has neglected refurbishment projects which become relevant due to an aging building stock in Sweden and Europe. Various actors are involved in refurbishment projects which makes it important to study each actor as well as tensions between them. By using a service ecosystem perspective and relying on 38 interviews, this paper aims to investigate tensions and barriers between actors within the service ecosystem of CDW for refurbishment projects in Sweden. Based on the results, spatial barriers are the most mentioned barrier which also create the highest number of tensions between project and contractor mother firm, subcontractors, waste recycling firms and society/citizens. The majority of the tensions are found between projects and the contractor mother firms, followed by tensions between projects and clients and projects and subcontractors. Unlike previous studies investigating only one of the actor's waste management practices, this paper contributes by investigating the interactions between seven different actors which is important for improving waste management practices in refurbishment projects.

## KEYWORDS

Building-refurbishment; waste management; service ecosystem; actor-to-actor tensions

## Introduction

The Architecture, Engineering and Construction (AEC) industry is one of the top contributors of waste generation. According to the European Union statistics (Eurostat 2016), the AEC industry generates 34.7% of the total waste in the European Union. Construction and Demolition Waste (CDW) is often generated in construction projects by inefficient use of resources and consists of many different types of material and waste. Waste management practices typically include waste prevention, sorting of waste, reuse, recycle and disposal.

From literature and practice it is clear that waste management practices need to be improved (cf. Bakshan et al. 2017; Bosch-Sijtsema and Buser 2017; Teo and Loosemore 2001) and there are challenges and barriers on different levels which limit opportunities in the AEC industry.

Waste management literature is dominated by studies on new build. However, there is a lack of studies on CDWM for refurbishment projects (Bosch-Sijtsema and Buser 2017; Sezer 2017). Refurbishment projects have a different process for CDW than new-build projects, because refurbishment waste often contains mixed materials and demolition waste, which is more difficult to sort, recycle or re-use. In refurbishment projects, site space is often limited and tenants can remain in the building during refurbishment (Sezer 2017). Furthermore, refurbishment projects have different actors involved in the process in relation to new build, i.e. demolition firms, municipalities, inspectors for hazardous waste and specialized refurbishment contractors and

sometimes the tenants of the refurbished building. Compared to refurbishment projects, new construction projects are planned better, having less uncertainties, and the amount and type of waste generated during production are estimated easier and therefore managed better. Considering the generated waste amounts, it becomes important to study how to improve the management of refurbishment waste so that it does not only diminish influences on the environment but also reduces costs in projects.

Identifying barriers and challenges in order to improve waste management practices in refurbishment projects is particularly interesting owing to the aging building stock in Sweden and Europe. Today, 34% of the on-going projects in Sweden are refurbishment projects.<sup>1</sup> Studies on waste management address different phases of construction project delivery processes as static stages, but waste management strategies are not applicable to every type of project, site and material (Ajayi et al. 2015). Many of these studies follow the construction project management phases and Goods Dominant logic (GD logic). The GD logic refers to an approach focused on units of output like products, material or waste. However, for CDW the lifecycle of material to waste is more relevant and an approach focusing on the flow of knowledge and skills becomes important, i.e. a Service Dominant Logic (SD logic) (Vargo and Akaka 2012; Vargo and Clavier 2015). In this logic, services are defined as the application of specialized competences (knowledge and skills) through deeds, processes, and performances for the benefit of another entity or the entity itself (Vargo and Lusch 2014). A SD

logic considers all social and economic actors as resource integrators and active participants of value creation (Vargo and Akaka 2012). These authors propose the introduction of a service ecosystem based on the SD Logic. The service ecosystem provides a framework to study the interaction and value cocreation of multiple systems. Service ecosystems are defined as 'relatively self-contained self-adjusting systems of resource-integrating actors connected by shared institutional logics and mutual value creation through service exchange' (Vargo and Akaka 2012). This view considers service systems to be emergent, dynamic networks of actors and their interactions (Vargo and Akaka 2012).

By discussing the different actors in the CDW service ecosystem and their interactions and tensions between these actors, a systems perspective concerning CDW can start to develop showing the relationships and dependencies of different actors in relation to waste. Adopting a service ecosystem perspective gives a more holistic perspective on the flow of waste in relation to a project management perspective.

Hence, the aim of this paper is to investigate tensions and barriers between actors within the service ecosystem of CDW for refurbishment projects in Sweden. The contribution of the paper lies in using data from the different ecosystem actors to give insight in the different institutions and tensions between the actors of the ecosystem in relation to waste in refurbishment projects.

The paper is structured as follows. Literature concerning CDW management in both new-build and refurbishment projects is reviewed in section two. In section three, the method of the study is discussed in which 38 interviews were held concerning refurbishment waste challenges on the construction site. Section four presents the results. The results and their relation to the literature are discussed in section five and concluded in section six.

## Barriers and challenges for CDW actors

Barriers and challenges have been a popular subject in previous studies on CDWM for new construction, but, barriers for refurbishment are often overlooked (Bosch-Sijtsema and Buser 2017). Previous studies have identified CDWM barriers often for only one type of actor involved in a construction project, but not focusing on interactions and tensions between these actors. In this subsection, barriers for CDW stated in literature are discussed for different phases of new-build and refurbishment projects, which may give an indication of the different actors involved in waste management and possible tensions and barriers for CDWM between these actors.

Typically, a building construction project starts with the phases of design and procurement, followed by the construction phase and operation and maintenance phase which can conclude in refurbishment and demolition. The design and procurement phases have a major influence on waste generation and prevention. The actors usually involved in this stage are the architect, owner/client and sometimes the tenants or end-users. Mismatches between design specifications and materials cause large amounts of waste (Poon et al. 2004; Ajayi and Oyedele 2018), making it important that designers are aware of the technical aspects of construction materials as well as the process. Osmani et al. (2008) note that waste minimisation is not a priority during the design stage and that is because architects believe that most construction waste occurs during site operations. Lack of financial rewards and lack of client demands are other barriers

for why architects often do not focus on waste minimisation during design. According to Li and Yang (2014a) in refurbishment projects main causes of waste generation in design information are incompleteness, errors and uncertainty. When it comes to the procurement phase, Withana-Gamage (2011), argues that design-bid-build systems tend to lead to more waste generation due to late involvement of contractors, incomplete concept designs, tight tender processes, and problems of communication between design teams and contractors. Moreover, incomplete contract documentation harms the accuracy of ordering materials and scheduling as reported by Poon et al. (2004).

During the construction phase, a number of actors are involved like the main contractor, subcontractors, waste and recycling firms, owner/client, tenants, governmental agencies, society/citizens around the project, and suppliers. On-site sorting is one of the most common waste management activities during this phase. Wang et al. (2010) claim manpower is the most important factor for on-site sorting. Challenges for on-site sorting are difficulties of separating mixed waste when it is contaminated, limited incentives like a better public image, competitiveness, reducing project costs, and the lack of a market receiving recycled materials which makes it difficult for contractors to find incentives for on-site sorting (Wang et al. 2010). While for many new build sites on-site sorting has developed well, on-site sorting of waste for refurbishment projects is more difficult. For refurbishment projects, limited site space is one of the major reasons (Poon et al. 2004; Li 2012) impacting on-site sorting but also reduces opportunities for placing recycling equipment on construction sites (Tam 2009). Furthermore, having a refurbishment project in a dense city centre limits opportunities for placement of multiple containers for sorting (Sezer 2017). Recycling in refurbishment projects is often difficult because of the existence of asbestos, continued occupation of the building by users and large projects are often divided into small sub-projects (Hardie et al. 2011).

Contractors are the main actors of the construction process, playing a vital role for on-site waste management. According to Li and Yang (2014a), refurbishment contractors tend to rush, do not pay detailed attention to the accuracy of as-built-drawings and do not document small-scale refurbishment works well. In a recent study, Wu et al. (2017) analyse contractors' waste management behaviour in China, claiming that government supervision and economic viability are the most important factors for contractors. Moreover, most contractors are profit oriented and they carry out waste management for economic reasons than environmental reasons. A major barrier for waste management for contractors is the lack of incentives (Udawatta et al. 2015), however as Buser and Bosch-Sijtsema (2017) report, incentives can be through new business models and creating new markets for contractors.

On-site staff of contractors and subcontractors play an important role for CDWM. Lingard et al. (2000) note four major issues influencing site-based managerial staff's waste management from large contractors: availability of local infrastructure, local disposal costs, site staff's knowledge of waste management methods, and top management support for waste management. According to Teo and Loosemore (2001) waste management is given a low project priority unless managers make it a priority and provide the necessary supporting facilities, incentives and resources. Li and Yang (2014b) add last minute client requirement changes and incomplete or faulty contract documents as the most significant barriers reported by their site practitioners.

**Table 1.** Demographic characteristics of the interviewees.

Demographic characteristics			
Role	Type of organization	Experience	N = 38
Site manager	Contractor	17 years (5–35)	19
Sustainability expert	Contractor	19 years (18–20)	2
Project manager	Sub-contractor: Demolition contractor	17 years	1
Recycling firm manager	Sub-contractors: Waste recycling firms	18 years (5–30)	6
Sustainability expert	Architecture	20 years	2
Environmental specialist	Municipality	14 years (2–30)	4
CDW expert	Contractor association	20 years	1
Project manager	Clients and facility management firms	5 years	2
Sustainability expert	Clients and facility management firms	10 years	1

The majority of the refurbishment projects are carried out by subcontractors, however literature on subcontractors and their waste management practices is scarce. Subcontractors are blamed for bad waste management practices in refurbishment projects, with demolition subcontractors being the only exception (Sezer 2017). Li (2012) studies Australian SMEs during refurbishment processes and claims that subcontractors lack awareness and capabilities related to CDW. Due to a lack of financial and technical support, subcontractors are often not involved in waste planning and management.

A major actor in waste management is governmental agencies who set up policies concerning waste management. Oke et al. (2018) note inadequate formulation and application of policies, implementation being costly, lack of mandatory waste management guidelines, changing behaviour of citizens and lack of investments in development of improved waste management technologies as major challenges for CDWM. These are in line with an earlier study by Poon et al. (2013) claiming that at construction sites, recommended practices are difficult to realize because they are not practical, are comparatively more costly than traditional practices, and their implementation obstructs normal work and causes delays. Moreover, current legal frameworks are not sufficiently adapted to companies of all sizes (Gangoellis et al. 2014) and often are not specified to refurbishment projects.

### **Service ecosystem lens for waste management**

As discussed from the literature overview concerning waste, there are multiple actors and stakeholders involved. Frow et al. (2014) distinguish between a stakeholder perspective and an ecosystem perspective. Stakeholder theory views the different stakeholders as distinct and mutually exclusive and has been criticized for the static approach of the environment. The literature discussed above concerning barriers for CDW in refurbishment projects often takes a distinct view of the different stakeholders. Frow et al. (2014) discuss a broader perspective with interconnected relationships within a network, in which actions of the focal firm have indirect and direct effects of the other actors. A service ecosystem can give insight in how networks of individuals and groups of individuals are connected and how the ecosystem adapts to changes in the environment. In an ecosystem, actors co-create and share value (Vargo and Akaka 2012). Some actors are key players in the ecosystem, while other actors can influence the system less. Vargo and Clavier (2015) developed a conceptual framework for applying a service logic and service ecosystem perspective on project management and projects. They discuss projects as social, complex and dynamic systems in which multiple actors actively participate to co-create value by integrating operand resources (Vargo and Clavier 2015). The operand

resources are resources that need to be transformed to provide value, e.g. material or in this case, waste. The perspective of service ecosystems for project management and in this case waste of refurbishment projects, gives insight in the lifecycle and complexity across all levels, the nature of the different resources, the influence on and by social resources and the construction of relationships at the level of actor-to-actor (Vargo and Clavier 2015). A network or service ecosystems approach has been used for studies concerning food waste (Baron et al. 2018), but not for CDW.

### **Research design**

This paper is based on an inductive study of 38 semi-structured interviews focusing on identifying and analysing stakeholder barriers and challenges influencing waste management efforts in building refurbishment projects. The study focuses on Sweden in which new-build CDWM is relatively well developed. The Swedish Construction Federation (2015) has in cooperation with the industry developed clear guidelines for the handling of different types of waste, with the goal to develop a standard practice in the industry. An introduction of land fill tax and regulations on hazardous waste have been positive for Swedish CDW. However, there is less focus on CDW for refurbishment sites in the Swedish industry.

Interviews were held with two different groups, see Table 1. One set of 19 interviews were held with site managers from primarily renovation/refurbishment sites and focused on waste management on site in Sweden (i.e. the focal actors as mentioned in Baron et al. 2018). Site managers are from the three largest contractors in Sweden and majority of them had experience of both multifamily housing and office refurbishment. Experience of site managers varied from 5 to 35 years while the average was 17 years. All site managers were male. The interviews with site managers included questions about experience in earlier projects, such as the actions for dealing with waste taken on site, waste management practices in refurbishment projects compared to new construction, barriers of waste management and the connection between the contract type and waste management practices on refurbishment sites. Although site managers are ‘the king[s] of construction sites’ (Gluch and Räisänen 2012), their decisions are influenced by other actors which makes it crucial to identify the actors within the service ecosystem of CDW for refurbishment projects and understand the tensions between them. With help of the interviews with site managers, insight was gained in the different actors that interact with the focal actors of the project. These different actors were interviewed in a second set of interviews.

The second set of interviews was held with a larger group of actors in Sweden who are all involved in waste management but



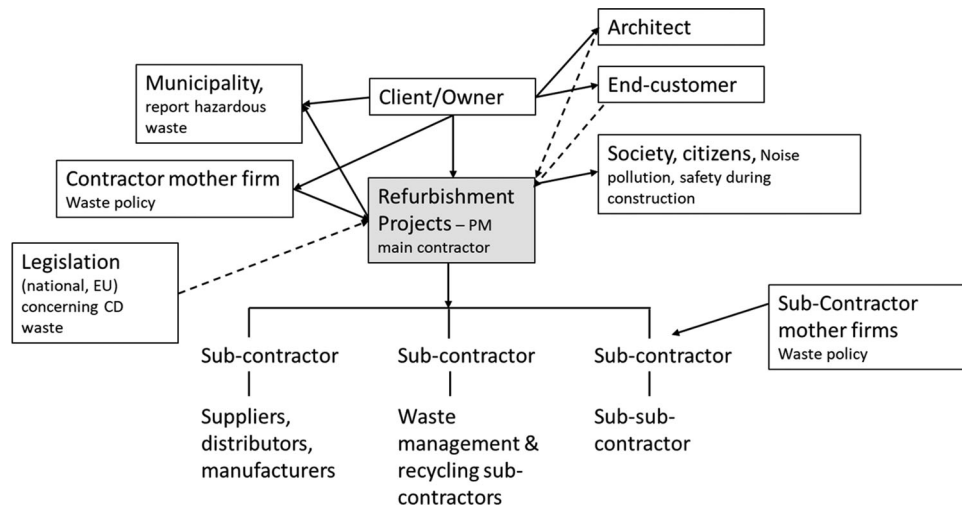


Figure 1. Project ecosystem for refurbishment projects focused on CD waste.

from different disciplines, these actors comprise the service ecosystem on micro (project level), meso (extended project level) and macro (societal) level (cf. Baron et al. 2018). The second set of interviews focused on waste management in general, the activities of different actors in the lifecycle of material to waste, and the barriers of waste handling of refurbishment waste. In this phase 19 interviews were performed with the following stakeholders: contractor's sustainability expert (2), demolition contractor (1), recycling firms (6), architect (2), municipality (4), industry representatives (e.g. contractor association – 1 interview), clients and facility management firms (3). Sustainability experts were both females, working at two different contractors and had around 19 years of experience. One project manager from a demolition subcontractor was interviewed, the interviewee was male and had 17 years of experience. Recycling firm managers were from three different waste recycling firms, were all male and their experience varied from 5 to 30 years. Architects were female, working as sustainability experts with 20 years of experience. Four interviewees work at the same municipality as environmental specialists and one of them was female. Two of them had 20 and 30 years of experience, while the other two had only 2 and 5 years of experience. The interviewee from the contractor association was a female expert of CDW with 20 years of experience. Interviewees from clients and facility management firms work as project managers (2) and sustainability expert (1), one of them was female and together they had around 8 years of experience in average.

In total 38 semi-structured interviews were held, most interviews were held in Swedish (sometimes English), were between 30 and 60 minutes long and were recorded and transcribed. Interviews were held both face-to-face as well as via telephone/video connection. All interviewees were guaranteed anonymity and were informed about the study and how the material would be used.

Instead of interviewing various actors, a single case study approach could be used. However, refurbishment projects vary widely from small to large refurbishment, from office refurbishment to multi-family housing refurbishment, and CDW practices are expected to be subject to a number of sources of uncertainty. Therefore, instead of studying a few refurbishment projects as cases that would provide a limited set of data to explain tensions and barriers between actors within the service ecosystem of CDW for refurbishment projects, 38 interviews were carried out

with a larger group of actors who are involved in waste management. By considering size and type, future studies can categorize refurbishment projects and select representative cases for each category in order to investigate tensions between actors within the service ecosystem of CDW for each category and compare.

For the analysis, the data was coded systematically and went through stages of naming data, comparing data incidents and memoing (Corbin and Strauss 2008). First, two authors coded data separately, then these authors discussed the codes together and jointly named the final codes. After the coding, the themes were categorized and ranked according to the number of incidents that were mentioned. The coding was related to the different actors their interactions and tensions that are relevant for refurbishment projects and CDW.

### Waste management tensions between refurbishment actors

Based on the interviews, challenges and tensions between the actors of the ecosystem of waste management in refurbishment projects are presented. The actors of the service ecosystem were found from the interviews and are presented in Figure 1. The focal actor of the service ecosystem is the project (project management team) which is connected through either contractual or more informal relationships to different actors. These actors are the Contractor mother organization, the Client/owner of the project, different subcontractors, i.e. demolition firms, HVAC, electricity, as well as waste and recycling firms, suppliers of material, tenants or end-customers and society or citizens that represent social interests of the project like noise pollution, safety and other disturbances. The final actors are governmental and legislation agencies, i.e. municipalities, who set guidelines and legislation for dealing with waste, primarily hazardous waste.

### Unpredictability of refurbishment

The unpredictability of refurbishment projects, mentioned by 13 interviewees, creates tensions between different actors, i.e. the project and the contractor mother firm as well as the project and the client/owner actor. Compared to new construction, refurbishment projects are full of uncertainties. Interviewees acknowledged that drawings might be wrong, there might be changes

from drawings due to new client demands, or hazardous chemicals can be discovered during refurbishment, meaning that extra activities and time are required. Moreover, the amount and quality of waste removed from buildings is difficult to predict and makes it difficult to plan waste management. These factors create tensions with both the contractor mother firm in terms of budget, planning and resources needed for the project as well as tensions with the client in terms of fulfilling the requirements of maintaining the stated budget and time limits of the project. The unpredictability requires adaptations for the projects and waste handling and a close interaction with the client as well as the contractor mother organization is needed.

### ***Spatial barriers***

Spatial barriers were mentioned by 34 interviewees as the main barrier for waste management in refurbishment projects. The lack of space on refurbishment sites is acknowledged by all the interviewed actors especially the site managers, and it clearly limits the number of containers which can be placed on site and leaves no space for sorting or recycling equipment. This aspect creates tensions with the contractor mother firm in terms of sorting on-site as well as the planning of logistics and material deliveries. The contractor mother firm often has policy documents, guidelines and performance measurements on sorting on-site which are difficult to fulfil for refurbishment projects. The lack of space creates tensions with the different subcontractors and waste recycling firms due to a lack of working space on site as well as a difficulty for sorting on site. Site managers also stated that projects located in dense areas, particularly in city centres suffer more from limited site space as well as limited space in surroundings of the refurbishment site. Refurbishment projects in urban areas influence society and citizens in terms of disturbances and noise which can influence the reputation of the project and firms involved or adapt the working space (limiting the space) and working hours of the project.

### ***The amount of waste changes during the project (mentioned by 17 interviewees)***

Site managers acknowledged that amount of waste varies during the construction phases of refurbishment projects and at certain times there is too much waste on site to sort it carefully. Both site managers and other actors including waste recycling firms mentioned that weight of specific waste can make on-site logistics difficult, for example the heavy weight of concrete. Some additional waste on site is coming from packaging material due to ordering new materials, while other actors (e.g. the waste recycling firms) mention that some material is not stored securely and is damaged on site due to weather conditions, this material cannot be used when it is damaged and becomes waste. The type and amount of waste determines the waste management activities for refurbishment projects. For example, there are often hazardous chemicals in old buildings which are discovered before or during the refurbishment process. Demolition waste being polluted with hazardous chemicals makes it difficult to reuse or recycle. Moreover, building parts are often old and in bad condition which makes it difficult to reuse them and often waste cannot be sorted but becomes mixed waste. These barriers create tensions with the contractor mother firm in terms of their on-site sorting policies as well as with different subcontractors in terms of planning for waste on site in different refurbishment phases. Regular interaction

between the different actors is necessary to adopt dynamically to different amounts of waste over time.

### ***The inflexibility of project contracts***

One site manager claimed that in design-bid-build contracts, they have limited flexibility since they must follow the drawings from the designer and cannot select whichever material they would like to use. Others, like the client and contractor mother firm acknowledged that the contract type does not always clearly discuss the CDW requirements or the possibility for re-using materials from refurbishment projects. According to site managers, most things are decided already in the tender phase which is done by the contractor mother firm and the client, limiting the flexibility on the refurbishment project when it comes to waste management.

### ***Lack of a systematic and shared approach***

A number of interviewees mentioned the lack of a systematic approach in waste management for refurbishment as a barrier (mentioned by 19 interviewees). Interviewees mentioned that there was a lack of a good system for on-site recycling. Furthermore, the variation in refurbishment projects and their unpredictability makes it difficult to develop standardized ways to deal with waste. When it comes to sorting of waste, it is not easy to separate materials from each other due to the mixed waste of demolition and refurbishment. Furthermore, interviewees mentioned that it was difficult to trace waste in these projects due to a lack of documentation. This barrier creates tensions with the contractor mother firm who often has a more standardized approach for new build construction and a policy for sorting waste on site, however, due to the difficulties mentioned above, for contractor mother firms it has been difficult to develop such a standardized approach for refurbishment. Many of their waste policies have primarily focused on new build projects instead of refurbishment projects. Also, the waste recycling firms discuss that the waste management on site could be adjusted so that it would fit better with their own waste handling.

Between the project (PM) and subcontractors, it was found that there were few shared beliefs or practices in terms of waste management (discussed by 13 interviewees). The lack of shared beliefs creates tensions between the project and subcontractors. Interviewees mention that there are many different people on site and different subcontractors that constantly change in the different construction phases, which makes it difficult to create shared practices for all actors on site. When it comes to the interaction and relationship between site managers (project) and subcontractors, site managers complained about subcontractors. Site managers claimed that subcontractors are not performing well when it comes to waste management and it is difficult to punish them with extra costs since this might create tensions on refurbishment sites. One site manager added that as main contractors, they are poor in transferring responsibility to subcontractors and monitoring their waste management performance. Other actors like the client identified two barriers related to the project, claiming they need to trust contractors that they will carry out their tasks as promised and also trust that the contractor is in charge of the subcontractors.

### ***Maintaining project institution***

One of the barriers mentioned by interviewees is the normative institution of project organisations and construction projects with a major focus on time and cost (mentioned by 31 interviewees). Many site managers acknowledged that they are under time pressure in refurbishment projects, which makes it difficult for them to prioritize waste management. The high time pressure implies that demolition phases in refurbishment projects must be performed very quickly. Moreover, one site manager added that smaller projects are more problematic since both time and budget are limited in such projects and they do not see economic benefits of managing waste in such small amounts. The strong focus on costs was mentioned many times by site managers. According to the site managers, on-site sorting of waste can be as costly as sending waste to an off-site sorting facility and it is difficult to find a balance between these two alternatives. Site managers believe that the more time they dedicate on waste management, the more costly it will be. Barriers related to costs are not only associated with sorting of waste, but site managers also mentioned that reuse of old materials is an expensive practice. The maintaining of the project institution is strengthened by the contractor mother firm who is keen on making a profit in the project and cost and time are major performance measures. A similar tension is seen from the subcontractors, the subcontractors could handle waste more on site, but this would cost the project more in finances, resources and time, therefore waste is often less prioritized.

Another tension that is discussed is the beliefs of the clients in waste and recycling (mentioned by 11 interviewees). For especially refurbishment projects, clients feel that a focus on waste and recycling is a trade-off for price/performance. One site manager mentioned that clients do not want to pay for the extra costs associated with waste management. Interviewees also mentioned that sometimes clients take the additional costs of shipping mixed waste to recycling firms, due to time limits and manpower costs for additional sorting onsite. In this case, the clients are also maintaining the project institution with a strong focus on costs and time.

### ***Lack of client knowledge***

From the interviews (mentioned by 12 interviewees) it became clear that the clients had a lack of knowledge in relation to waste management, which makes it difficult to have precise demands from the client concerning waste management. They also added that knowledge of what can be re-used and how it can be re-used in refurbishment sites is missing. The client as well as site managers mentioned that follow-up of waste management on site was often not performed by the client due to the lack of time and knowledge. This lack of knowledge and follow up from the client creates tensions between the project and the clients/owner meaning that the project management finds it difficult to gain insight in the demands and requirements of the client concerning waste which is often reflected in a lack of requirements concerning waste in the contract. This implies that the decisions on waste handling are often made by the site manager who bases their decisions on interactions with the waste recycling firms, and the policy of the contractor mother firms.

### ***Safety for tenants and citizens around a refurbishment project***

Barriers due to safety issues were only mentioned by site managers (12 interviewees mentioned this). When there are tenants living in a building during refurbishment, contractors need to be careful while demolishing and find solutions for handling the waste and dust. Furthermore, waste simply cannot be dropped from a certain height. Waste containers can be filled by tenants or neighbours and contractors need to be extra careful with placement of containers for fire safety. In order to avoid risks of waste starting to burn and risking houses around, contractors need to shelter containers. Furthermore, with refurbishment projects disturbances, dust and noise pollution impact society close to the project. While the tenants and citizens do not have a direct relation to the focal actor, the project, they influence the refurbishment work. The refurbishment project has to pay attention to safety of these actors, as well as trying to diminish disturbances, dust and noise pollution. On the other hand, these actors can also influence the project in terms of complaints to the municipality concerning disturbances and can for example use the containers for their own waste which makes it difficult to sort the waste carefully.

### ***Legislation lacking from governmental agencies (mentioned by 11 interviewees)***

Site managers stated difficulties of obtaining permission from municipalities for placing containers on the street as a barrier. Other stakeholders find legislation insufficient and mention that current Swedish legislation only focuses on hazardous waste management, while they also add that there is not a good inventory system for refurbishment projects. For Swedish refurbishment projects, the municipality is responsible for giving the go ahead after a 'neutral' inspector has inspected the building for especially hazardous waste. The role of the inspector is rather relevant, and it was mentioned that sometimes inspectors miss particular types of waste. Furthermore, the inspectors from the municipality only focus on hazardous waste and other types of waste are neglected because this is not demanded by the municipality for gaining the permit to refurbish or demolish a building. The project perceives a tension in terms of lack of legislation, lack of incentives and guidelines on how to improve waste handling for refurbishment.

Furthermore, interviewees acknowledged that it is not only waste management related legislation influencing them, but also legislation related to fire and safety. For example, on refurbishment sites, they are not allowed to place containers close to the building due to fire safety.

The municipality requires sorting on site, but this is sometimes difficult due to lack of space. Another barrier mentioned was that sometimes client demands go against the local governmental agency demands. Interviewees also mentioned that while governmental agencies would like to see more reuse of material, but there is a lack of a sales market for this material. From the interviewees it became clear that the municipality was open for more interaction concerning these issues to see how they could follow up and interpret the laws. However, there were no discussions between the project, contractor mother firm, client and municipalities on how to reduce these tensions.

**Table 2.** Overview of the different actors and tensions between actors for a service ecosystem concerning waste for refurbishment projects and their internal and external pressures.

Barriers/tension	Actor-to-actor	Interaction	Waste management	Tension
Unpredictability of refurbishment projects	Project – Contractor mother firm	Employment, contract	Waste is connected to costs – more waste means higher costs	Internal pressures related to planning, time and budget
	Project – Client	Contract	Requirements from clients on waste sorting, handling	Tension to fulfil requirements in stated budget
Spatial barriers	Project – Contractor mother firm	Contract	Waste requirements for the site in line with company policy	Tensions concerning planning and logistics of materials and waste
	Project – subcontractors	Contract	Subcontractors follow the waste requirements for the site set up by PM	Tension toward subcontractors concerning lack of space in the work environment
	Project – waste subcontractors	Contract	Waste subcontractors can set up waste management requirements with the PM	The lack of space in many refurbishment projects makes it sometimes difficult to have multiple containers for sorting on-site
	Project – society/citizens	Informal		Pressure from society/ environment to minimize the work site so that the construction creates less disturbance for society and citizens
Waste changes per project phase	Project – Contractor mother firms	Employment, contract	Waste is connected to costs – more waste means higher costs	Internal pressures related to planning, time and budget
	Project – subcontractors/waste subcontractors	Contract	Subcontractors follow the waste requirements for the site set up by PM	Pressures on subcontractors in planning how much and what type of waste is on site in different phases
Contracts inflexible	Project – contractor mother firm	Employment contract	Contracts for the project are tendered between the contractor mother firm and client	Contracts can limit the flexibility in the project, e.g. limiting choice of materials or waste management choices
	Project – Client/owner	Contract	Requirements from clients on waste sorting, handling and usage of material/re-use of material	External pressure with clients in terms of contractual agreements and specifications
Lack of systematic approach to waste management	Project – Contractor mother firm	Contract	Waste requirements for the site in line with company policy	Internal pressure on site related to planning and organizing waste – there is no standard approach for waste management for refurbishment projects
	Project – Subcontractors	Contract	Subcontractors follow the waste requirements for the site set up by PM	External pressure to subcontractors due to lack of shared practices and beliefs concerning waste handling
	Project – waste subcontractors	Contract	Waste subcontractors can set up waste management requirements with the PM	The waste subcontractors feel that the waste management approach on site could be adjusted so that it would work better for their waste handling.
Maintaining project institution – strong focus on cost and time	Project – Contractor mother firm	Contract	Waste requirements for the site in line with company policy	Tension between project management and mother organization to keep the project in budget, and on time as main priorities. Focus on waste is less prioritized
	Project – Subcontractors	Contract	Subcontractors follow the waste requirements for the site set up by PM	Subcontractor pressure focus on diminishing cost and time. Focus on waste is less prioritized
	Project – Client/owner	Contract	Requirements from clients on waste sorting, handling and usage of material/re-use of material	Trade-off in relation to waste and total costs of the project (price/performance trade-off). Focus on waste is less prioritized when the project goes over budget and time.

(continued)



Table 2. Continued.

Barriers/tension	Actor-to-actor	Interaction	Waste management	Tension
Lack of knowledge	Project – Client/owner	Contract	Requirements from clients on waste sorting, handling and usage of material/re-use of material	Contractors find it difficult gaining insight in clients demands on waste due to a lack of knowledge on waste management from the client's side. This is often reflected in the lack of requirements and contractual elements concerning waste
Safety for tenants and citizens around a refurbishment project	Project – Citizens	Informal	Waste during the construction should not disturb the surrounding environment of the project	The contractor is responsible for all disturbances towards tenants/end-users during the refurbishment project as well as fire safety (noise, dust, waste etc.).
	Project – end-users/tenants	Contract through client/owner	Waste during the construction should not disturb end-users	The contractor is responsible for all disturbances towards tenants/end-users during the refurbishment project as well as fire safety (noise, dust, waste etc.).
Legislation is lacking	Project – Municipality/government	Legal	Guidelines and policies for handling hazardous waste	The contractor perceives a tension in terms of lack of legislation, lack of incentives and guidelines on how to improve waste

## Discussion

With the help of a service ecosystems perspective on waste management for refurbishment projects, the article discusses tensions and challenges between the interconnected actors within the network of refurbishment waste (see Table 2). Actions of the network as well as the focal actor can have indirect and direct effects on other actors (Frow et al. 2014) and the service ecosystem gives insight in how these actors are connected. The tensions discussed in the article give insight in how interactions between different actors are performed and how the ecosystem adapts to changes in the environment. Applying a service ecosystems for project management and in this case waste of refurbishment projects, gives insight in the lifecycle and complexity across all levels, the nature of the different resources, the influence on and by social resources and the construction of relationships at the level of actor-to-actor (Vargo and Clavier 2015). Applying a service ecosystem perspective to project management draws attention to whom and what are integrating resources, meaning that all actors in the ecosystem are resource integrators and not only the main stakeholders (client, contractor, subcontractor) are integrating resources and exchange value (Vargo and Clavier 2015), but also other actors like government and societal actors.

A major finding for refurbishment projects is the unpredictability of refurbishment which makes it complex to plan the project on time and within budget. It is clear that proper feasibility studies to determine the cost and schedule of refurbishment projects are needed. The unpredictability of refurbishment is connected to the barriers of the lack of a systematic approach to waste management and the fact that for refurbishment there are different amounts and different types of waste on site over the project course. Both these barriers create pressures for the contractor firm as well as for the different subcontractors. A majority of the previous studies neglect how waste management efforts vary during different phases of a project, but according to the interviewees, amount and type of waste vary significantly in

different phases of refurbishment projects. Refurbishment projects often begin with demolition activities which result in large amounts of waste, which are often taken care of by demolition subcontractors. Towards the end of refurbishment projects, different types of waste are generated owing to various subcontractors involved (such as electrical, piping and HVAC) and pressure to deliver the project on time increases, which leaves no time for neither sorting of waste nor monitoring waste management performance.

From a contractor's role, building refurbishment projects are characterized by tight schedule, smaller budgets and lack of physical space. Lack of space was the most reported barrier by the interviewees, which is in line with results of previous studies (Poon et al. 2004; Tam 2009; Li 2012; Sezer 2017). Lack of space does not only influence on-site sorting attempts by reducing the number of containers on sites, but also limits opportunities for recycling (Tam 2009). On-site logistics, moving new as well as recyclable materials around and storing them are other activities harmed by lack of space in refurbishment projects. According to the interviewees, projects located in dense city centres have less space and tighter schedules, making waste management a low priority. The lack of space causes both tensions between the project and the contractor mother firm in terms of planning and logistics, but also causes tensions towards different types of subcontractors who have to deal with the lack of space. Another tension is with is the role of society in which the contractor tries to reduce the disturbance for society in urban settings, but thereby creates additional barriers for the project.

One of the main challenges common in the AEC industry and construction is the strong focus on costs and time and the project focus. Especially, maintaining the focus on the institution of a project creates tensions for the contractor as well as the subcontractors and clients where the focus is often on diminishing costs instead of reducing impact on the environment. According to the interviewees, time pressure is a major barrier in refurbishment projects, which forces refurbishment site managers to focus

on delivering the project on time, making waste management activities such as on-site sorting of waste less of a priority. From the interviews, the client's beliefs in waste and recycling are relevant for waste management and often there is a trade-off between price or performance. The additional costs for sorting or recycling waste usually are the major barriers against green practices. From a service ecosystem perspective, the interactions on different levels between the ecosystem actors (on project, multiple projects and society levels) are connected and influenced by shared structures and governance mechanisms providing context for these interactions. These shared structures can be viewed as institutions like values, beliefs and traditions (Frow et al. 2014; Vargo and Clavier 2015; Baron et al. 2018). In project management these interactions are bound by multiple institutions that might be in conflict with each other (Vargo and Clavier 2015). This is clearly seen in the case of practices and beliefs for waste management in refurbishment which can go against the project management institution focusing on cost and time.

The conflicting institutions between waste management and project management were also found between the project and subcontractors. There are many different types of subcontractors who all have different agendas and roles, which are not always clear to all other actors. Furthermore, a major tension was the lack of shared practices and beliefs between subcontractor and the project or even amongst subcontractors, which is also reported by Li (2012) and Sezer (2017). According to the interviewees, subcontractors have very diverse waste management practices and it is difficult to find ways to encourage subcontractors to improve performance in terms of waste management. However, since subcontractors carry out a large proportion of the refurbishment projects (Li 2012), it becomes relevant to consider subcontractors' waste management practice and performance while selecting them for refurbishment projects as suggested by Sezer (2017).

The role of the client has been shown to influence waste management practices. Without client demands, architects do not consider waste generation during the design stage (Osmani et al. 2008) and collaboration with clients is an important source of data for architects (Ali 2010). Last minute client requirement changes contribute to waste generation (Li and Yang 2014b) and refurbishment site managers' waste management efforts drop significantly without specific client demands related to waste management (Sezer 2017). Furthermore, the interviewees acknowledged that the client's knowledge of waste management is limited, meaning a lack of precise demands concerning waste management. This also explains the lack of monitoring or follow up on waste management by the client which is an important barrier to waste management in refurbishment projects. Contractors find it difficult to gain insight in client's demands on waste due to a lack of knowledge on waste management from the client's side. This is often reflected in the lack of requirements and contractual elements concerning waste.

Another relevant actor for the waste management ecosystem is the society/citizens and tenants of the refurbished buildings. For refurbishment projects especially in urban locations, the surroundings and society around the project become relevant in terms of disturbances, noise pollution as well as safety. Also, the tenants are important actors because they can stay in parts of the building during refurbishment. The society and tenants are creating tensions for the main contractor because they are responsible for the site and have a goal to diminish disturbances for society and tenants.

The role of governmental and legislative agencies is also important for refurbishment projects. The interviewees find legislation related to waste management insufficient, claiming that legislation mostly focuses on hazardous waste management. A lack of detailed specifications and strict supervision from governmental agencies is reported as a barrier by Wu et al. (2017). Hazardous waste is managed well on refurbishment sites because the legislation for hazardous waste is very detailed and strict. By developing the current legislation on waste management, considering different sizes and types of refurbishment projects as well as companies of different sizes (Gangoelle et al. 2014), waste management performance in refurbishment projects can be improved. Furthermore, interviewees acknowledged that it is not only waste management related legislation influencing them but also legislation related to fire and safety. On refurbishment sites, they are not allowed to place containers close to the building considering fire safety and getting permissions from the municipality for placing containers on the streets is not possible either. The actor of government and municipality has a major influence on the ecosystem of waste for refurbishment projects, both in terms of legislation, but also in the lack of regulations which leaves the handling of waste up to the other actors in the ecosystem.

From the study it becomes clear that for refurbishment projects there are a number of specific barriers and tensions between different actors that influence waste management. These barriers are related to the different actors and create tensions for other actors. Literature has neglected refurbishment projects in relation to waste management to a large extent and focused primarily on new build. However, in order to increase waste management and green practices, also refurbishment projects and their actors need to be studied in more detail. A focus on the service ecosystem of refurbishment projects gives an insight in the interactions and tensions between all the actors that influence these projects. Adopting a service ecosystem perspective gives a more holistic perspective on the flow of waste and the interdependencies of the different actors involved in the ecosystem. Some of these interdependencies create tensions and are counterproductive for developing value. For example, interviewees stated that company policies related to waste management are not always applicable to refurbishment sites, which is in line with findings of Poon et al. (2013) or certain legislations make it more difficult to deal with waste on-site. All the aforementioned tensions might be used as input to the risk identification process of refurbishment projects and these tensions and risks can be managed during the feasibility phase of projects. As a practical implication of the study it becomes relevant to develop clear waste management plans for refurbishment projects in which a systematic approach, clear requirements and demands, and clear guidelines for all involved actors are discussed.

## Conclusion

The AEC industry is one of the top contributors of waste generation and the industry is in need of better waste management practices. The aging building stock in Sweden and Europe makes it vital to develop specific methods for waste management in refurbishment projects, which have been neglected by research. In refurbishment projects various actors are involved in the process compared to new construction. By using a service ecosystem perspective and relying on 38 interviews, this paper aimed to investigate tensions and barriers between actors within the service ecosystem of CDW for refurbishment projects in Sweden.

Unlike previous studies of CDW-management where barriers are identified for only one or a few actors involved in a project, by relying on an ecosystem perspective, in this paper barriers were identified for seven different actors as well as investigating the interactions and tensions between these actors owing to the barriers. The most mentioned barriers are spatial barriers (34 times), followed by maintaining project institution (31 times). Spatial barriers create the highest number of tensions which are between project and contractor mother firm, subcontractors, waste recycling firms and society/citizens. The majority of the tensions of the CDW service ecosystem are between projects and the contractor mother firms, followed by tensions between projects and clients and tensions between projects and subcontractors.

The contribution of the paper is twofold: (i) identifying CDW-management barriers as well as tensions caused by barriers in refurbishment projects between seven different actors and (ii) introducing service ecosystem as a lens for studying CDW of refurbishment projects. This study is useful for each of the actors investigated, delivering a message about barriers for CDW-management as well as showing the interrelationships and tensions between the different actors. In order to gain a complete picture, future studies should include two other stakeholders, designers as well as waste recycling firms.

## Note

1. <https://www.sverigebygger.se/byggprojekt/aktuella>

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